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UNION OF SOUTH AFRICA.

DEPARTMENT OF MINES.

THE
OCHRE DEPOSITS
OF THE
RIVERSDALE DISTRICT,
CAPE PROVINCE,

BY

D. J. L. VISSER, B.Sc.
Publication of the Geological Survey Division.

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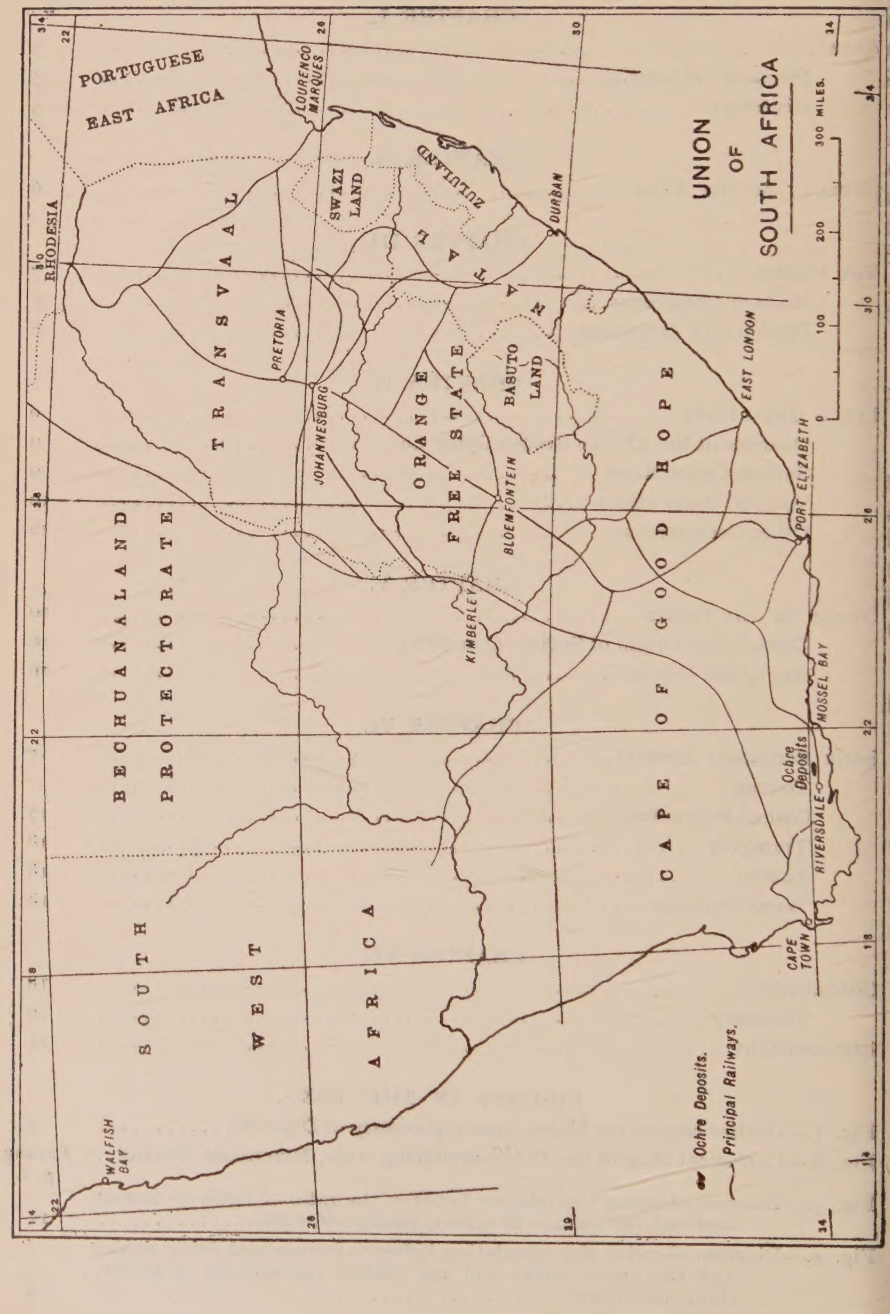
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BECHUANALAND PROTECTORATE
SOUTH WEST AFRICA
WALFISH BAY
CAPE OF GOOD HOPE
EAST LONDON
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I.—AREA.

Yellow and red ochre of good quality occur in the south-eastern portion of the Riversdale district, about 2 to 10 miles west and north-west of the village of Albertinia and north of the South African Railway to Mossel Bay. The mineral is quarried on the farms Tartouwa, Snymanskraal, Zoutpan, Zoutvley, and the southern portion of Drooge valley, while an abandoned quarry is situated on Buffelsfontein, about 1½ miles east of Albertinia. During prospecting operations ochre has been located on Tygerfontein; ochreous shales have a fairly wide distribution, occuring over the central and northern portions of Drooge valley, Tygerfontein, on the Albertinia commonage, Botteliersfontein and Buffelsfontein. The area over which extensive alteration in the Bokkeveld shale has been observed measures roughly 18 miles from east to west and 6 to 8 miles from north to south.

Physical Features.

The area is one of little relief, being part of an extensive and gently sloping peneplain less than 1,000 feet in altitude south of the Langeberg. Into this peneplain the rivers and streams have incised their channels, sometimes to over 100 feet. In doing so they have eroded away most of the superficial deposits covering the Bokkeveld and exposed the fresh underlying shales deeper down, so that the country as seen today is part of a highly dissected peneplain.

Historical.

The value of ochre as a material for export was first realised by the late W. R. van As of Riversdale, about 1922, when samples from small quarries opened by local farmers were submitted to overseas concerns with a view to obtaining markets. Prospecting was commenced on the northern portion of Zoutpan but continuous mining on a small scale followed only some 4 or 5 years later, extending gradually as the ochre gained favour on the overseas markets—both in England and on the Continent.

During the second half of 1928 further ochre deposits were located by H. F. Matfield of Mossel Bay on the farms Swartwater (eastern portion of Tartouwa) and on the southern portion of Drooge valley. Little developing was done on those properties, until through the interest and intervention of the Golden Valley Ochre and Oxide Co., of Bristol, England, the African Golden Ochre Co., was floated in 1930, and started quarrying on an extensive scale.

The Sunrise Ochre Mines having acquired the rights for quarrying ochre on the farm Paulsfontein (north-western portion of Zout vley) began prospecting early in 1930 and followed immediately with quarrying. This company's production was for some time sold to the African Golden Ochre Co.

II.—GEOLOGY OF THE AREA.

Over the producing area the following stratigraphical succession is revealed :—

Surface quartzite—of late Tertiary age.

White, cream or yellowish clays—weathered Bokkeveld.

Bokkeveld beds—Cape System.

The unaltered Bokkeveld beds are rarely exposed. The beds are highly argillaceous, greenish-grey, and weather to a reddish or brown clayey soil. Where there has been enrichment in iron the shales are coloured a deep red. Isoclinal folding is the dominant structural feature throughout, the dip varying from 30° south to nearly vertical. A secondary cleavage is usually developed and this combined with the easy weathering of the rocks tends to destroy traces of the original stratification. The latter is sometimes found preserved in hard limonitic bands exposed in the ochre quarries, often showing highly contorted foldings on a small scale. Small quartz veins, though not abundant, are quite common.

A layer of white to yellowish clays usually underlies the surface quartzites. They are soft with a soapy feel and fairly aluminous. Small sand grains and lumps of vein quartz occur at random in them ; the more coloured varieties are often distinctly gritty. As a rule the clays immediately below the quartzites are white, becoming more coloured with increasing depth. However, white clays have been found associated with red and yellow varieties at depths of over 20 feet.

The clays have not been transported to their present position but have been derived from the underlying Bokkeveld shales through weathering *in situ*. At the Sunrise Ochre Mines the original steeply inclined bedding planes can still be traced within the clays.

A capping of surface quartzite, not more than 6 feet thick at the quarries, in most cases overlies the clays. The rock is finegrained, siliceous, yellowish-grey in colour, and consists of angular quartz grains scattered in a matrix of amorphous silica—a texture characterising the so-called "Findlings Quartzit." At many of the ochre quarries the lower portion of the rock is seen to be granular and porous while the upper portion is a hard thoroughly silicified mass ; at Van As' ochre mines it carries angular fragments of white vein quartz measuring more than ½ inch across.

Nodules of limonite are common in certain parts of the area. Large ones, often three or four grown together, have been seen on the surface on Snymanskraal. Where they occur within the clays, an ochre of inferior quality surrounds them.

III.—The Ochre.

The term ochre as commonly used applies to earthy and pulverulent forms of the minerals hematite and limonite which are almost invariably more or less impure through the presence of other metallic oxides, silica and argillaceous matter. The colour of an ochre depends on the chemical composition of the principal constituent. Thus hematite, the anhydrous ferric oxide, gives rise to red ochres, while the hydrated ferric oxides have shades of yellow, these shades varying according to the percentage of water combined with the ferric oxide. The following are common hydrated ferric oxide minerals :—

Limonite, 2 Fe_2O_3. $3H_2O$.......	Yellow, brown.
Xanthosiderite, Fe_2O_3 .$2H_2O$...	Golden yellow to brown.
Göthite, Fe_2O_3. H_2O..........	Yellow, brown, brownish black.
Turgite, $2Fe_2O_3$. H_2O.........	Red to reddish brown.

Any combination of these minerals, or all of them in varying amounts, may be present in an ochre.

The base of these pigments is usually clay mixed with more or less silica. In the case of the Riversdale ochres the latter predominates. In all cases they are the results of chemical and geological processes active within the zone of weathering.

Mode of Occurrence.

Good ochre in workable quantities is generally found from a depth of about 15 feet from the surface downwards. It occurs within the white or coloured clays as pockets which may contain a few handfuls to lenticular bodies yielding several tons of ochre. The smaller masses are of irregular shape and bear no relation to the strike and dip of the Bokkeveld. The larger lense-shaped bodies have their longer axes in an east-west direction, conforming with the strike of the Bokkeveld, and extend approximately vertically downwards, thus agreeing with the dip of the series in the surroundings. Within the white aluminous clays the bodies of ochre are sharply defined, where the clays are coloured there is a gradual transition from good ochre to clay, in which case picking becomes the work of an expert. Around the hard limonitic bands and nodules an inferior quality of ochre, which is hard and gritty and difficult to quarry, is found. The colour is good but it requires addition of a base of white lead in order to hold on to anything. This material is known as "Peru" to the ochre miner. Farther away from the hard bands the quality of the ochre improves, but complete hydration was evidently not attained, as very little first grade ochre is found under these circumstances.

Deposits of red ochre have been opened up at the Sunrise Ochre Mines and at one of Van As' quarries. It occurs within slightly coloured clays associated with yellow ochre, the latter surrounding the red partly.

The Riversdale yellow ochres have a fairly uniform golden yellow colour, which is improved by removal of ochre of inferior quality. The associated red ochres have a brilliant red colour.

Preliminary Treatment.

As the natural colours of ochres depend on the degree of oxidation and hydration and the kind and amount of impurities present, these facts have to be considered in the treatment of the pigment.

That temperature and moisture have a vast influence on the iron hydrates has been shown by several investigators. Elsden (4)* states that in the case of the laterites in India, the yellow xanthosiderite soon weathers to a reddish brown turgite, owing to dehydration. In the hot and arid regions of South California the soils are dark red in colour, the iron being in the form of hematite instead of the hydrous forms göthite or limonite. Dehydration also takes place in the hot regions of the Southern Appalachians, where the air is comparatively humid.

According to Van Bemmelen, (*vide* Tomlinson—15) on standing in a dry medium at ordinary temperatures the colloidal ferric hydrates gradually approach the composition $2Fe_2O_3$. H_2O, beyond which the percentage of water is not reduced without the application of much higher temperatures. Under water or in air of moderate humidity they have not been shown to lose water beyond the composition Fe_2O_3., $2H_2O$, except at temperatures above 50°C., (i.e. 122°F., a temperature never reached on the ochre fields).

It is therefore clear that under ordinary climatic conditions prevailing in the ochre-producing area, the ferric hydrates in the ochre can undergo a process of dehydration and cause a change of colour in the pigment. This fact has been observed by most of the producers, especially when they expose the ochre to direct sunlight during the warmer seasons. Where drying is required, the process must be carefully controlled.

The ochre as it comes from the quarries is in irregular lumps containing too high a percentage of moisture for immediate shipment. It is therefore spread on large drying floors and exposed to the sun for one to five days according to weather conditions. The dried lumps of ochre pulverise readily.

A small quantity of saline matter is present in the ochre ; it reveals itself as a white film on the surface of the lumps when they are exposed to direct sunlight. This saline matter is hygroscopic (probably $CaCl_2$ or $MgCl_2$) and greatly affects the percentage of moisture in the ochre. For export a maximum of 10 percent. moisture is allowed by overseas buyers, a penalty of 1 percent. of the purchase price for every 1 percent. moisture in excess of the allowed 10 percent. being levied by the buyer. Imperfect drying and storage facilities and carelessness and delay in shipping is usually the cause of too high a moisture content. For that reason one producing concern dries its ochre in roofed sheds that allow for a free circulation of air, the drying period being about 5 days. This produces no white film on the lumps of ochre, and the management states that since following this method and shipping at Capetown they have not been penalised for excess of moisture.

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* The figures in parenthesis refer to the bibliography at the end of the paper.

Before shipping, the ochre is tested at the quarries. This is done either colorimetrically or chemically. The methods are crude and unreliable and the standards of comparison differ among the different companies as well as with those of the overseas buyers, so that actually very little information regarding the nature of each shipment is gained from the tests.

IV.—Field Operations.

The three operating concerns in the field are the African Golden Ochre Co., Sunrise Ochre Mines, and Van As' Ochre Mines, (now Warden and Hotchkiss, Ltd.). The methods of mining as practised by the various companies are essentially the same. Open quarrying is resorted to, the work being mostly by pick and shovel while tramming is done by means of wheelbarrow or trolley. First the overburden of soil and surface quartzite is removed to expose the clays. Trenches are then cut in the clays until a body of ochre is struck. The ochre is carefully picked out and followed by cross trenches or short tunnels from the main trenches. As work proceeds to deeper levels the overlying clays are also removed. In this way a rectangular paddock is formed, which gradually grows in length, breadth and depth. Explosives are occasionally used on the surface quartzites, hard limonitic bands and masses of hard ochre.

Quarries of the African Golden Ochre Co.

The company has two quarries, S.W. and J.O., on Swartwater (one of which, J.O., has been abandoned since), two on Snymanskraal namely Z.P., and B.N., one on Zoutpan and one, L.H. on Drooge valley. Each of the quarries is situated either on top of a quartzite capped rise, or against the slope near the top. Between one and five feet of quartzite has to be removed to expose the clays. Good ochre is quarried from a depth of 12 feet (though occasionally occurring higher up) to 25 feet below the surface. No greater depth has been reached yet.

Mainly first grade ochre is produced and exported to the Golden Valley Ochre and Oxide Co., of Bristol, England. Second grade ochre is also produced and exported according to demand overseas.

Sunrise Ochre Mines.

There are two producing quarries on Zout Vley, about ½ mile apart and situated on gently rising ground. The quarries are roughly rectangular pits just over 20 feet deep. About 2–4 feet of quartzite cap the clays in which ochre has been found at a depth of 6 feet below the surface. Larger deposits of excellent ochre occur from a depth of 16 feet downwards. A small quantity of red ochre is produced as well as some of the hard variety ("Peru") of yellow ochre.

Van As' Ochre Mines.

Two quarries are situated on the northern portion of Zoutpan, one on the main road from Riversdale to Mossel Bay, the other approximately a mile to the south. From 3 to 4 feet of surface quartzite has to be removed and good ochre in fairly large quantities is quarried below the 15 foot level. This concern produces a super grade ochre of exceptionally good quality, all of which was being exported, as well as an A–grade ochre of which about 3 tons are produced per ton of "Super." The latter has been sold to Warden and Hotchkiss, Ltd., of Durban, to be refined and ground for selling as dry or mixed paint.

Other Occurrences.

In the Swellendam district, about 20 miles west of the village on the farms Muurkraal and Klaaskaffersheuvel the African Golden Ochre Co., formerly quarried some ochre but on account of the unpayability of the deposits the quarries were abandoned.

From the Bredasdorp district ochre has been reported on the farms Diepkloof and Verfheuvel, from where yellow ochre and red oxide pigments had been supplied to Winsor and Newton.

In the Humansdorp district some soft ochreous shales were observed by the writer on the farm Hartebeestefontein, in railway cuttings about a mile north of Billson siding. They form part of the steeply inclined Bokkeveld shales near the contact with the T.M.S. and are covered by a thin layer of highly silicified tertiary conglomerates.

V.—ORIGIN OF THE OCHRE.

Before coming to this point, the following analyses of ochres, shales and clays are of interest :—

	1.	2.	3.	4.	5.	6.	7.	8.
SiO_2	24·52	12·66	56·85	65·17	39·81	63·09	69·78	67·58
Al_2O_3	10·18	5·28	27·10	22·58	5·47	19·91	14·98	15·62
FeO	·22	·39	·11	·17	·29	3·05	2·09	3·76
Fe_2O_3	51·36	71·65	2·87	1·68	45·28	2·80	2·85	2·10
CaO	·22	·35	·29	·29	·45	·26	·50	·48
MgO	·75	·58	·87	·87	·87	2·40	1·87	2·43
K_2O	·43	·46	·180	3·06	2·13	2·32	2·42	2·01
Na_2O	·42	·61	1·51	1·83	1·76	1·67	2·04	1·95
H_2O-	1·58	1·00	·75	·26	·68	·42	·28	·15
H_2O+	10·94	6·61	8·64	4·93	3·64	4·98	3·33	3·58
TOTAL	100·64	99·59	100·79	100·84	100·38	100·90	100·14	99·66

1. Yellow ochre	Van As' northern quarry, Zoutpan.
2. Red Ochre	Van As' northern quarry, Zoutpan.
3. White clay in which ochre occurs altered Bokkeveld.	Van As' northern quarry, Zoutpan.
4. White clay; altered phase of Bokkeveld.	Tygerfontein, north of Albertinia.
5. Red ferruginous phase of Bokkeveld shales.	Tygerfontein.
6. Weathered Bokkeveld shale	Tygerfontein.
7. Bokkeveld shale	Near Zoetmelks river, on Riversdale-Albertinia road.
8. Bokkeveld shale	From road cutting, 1½ miles from Riversdale.

Analyst: C. F. J. van der Walt.

From a perusal of the analyses the following may be deduced :—

(1) There is a definite decrease in the percentage of silica as one passes from shales through clays to yellow ochre and on to red ochre.

(2) From shale to clay there is an increase in the alumina content, corresponding with the decrease in silica.

(3) The percentage of FeO decreases from shale to clay while the Fe_2O_3 content remains practically unaltered to increase, rapidly in yellow ochre and more so in the red ochre.

(4) There is a low percentage of Na_2O, K_2O, MgO and to a certain extent CaO in the ochres compared with the shales and clays; these constituents have apparently been carried away in solution. These facts point to an enrichment in iron at the expense of mainly silica, and to a lesser extent alumina, alkali and alkaline earth constituents.

In order to explain the origin of the ochre satisfactorily, one has to find a reasonable explanation regarding the source of the iron. A source that suggests itself is the Bokkeveld shales, and the iron that went to form the ochre came from the white clays in which the ochre occurs. It is apparent from the analyses that mainly ferrous iron played an active role in the ochre formation, i.e. was dissolved, transported and subjected to chemical change. Taking the percentage of ferrous iron that was removed from the clays, i.e. to transform a shale into a clay, one finds on calculation that the quantity in a layer of clay 15 feet thick—the depth below which payable ochre occurs—over the producing area (measuring roughly 18 miles from east to west and 8 miles from north to south) is more than sufficient to account for all the known deposits of ochre.

The relation of the colours of shales, clays and ochres to the ratio of ferric and ferrous iron contained in them throws further light on the process of ochre formation. This is best illustrated graphically, by calculating the percentages of iron in Fe_2O_3 and FeO from the analytical data and then plotting ferric iron as ordinates and ferrous iron as abscissae, according to Tomlinson's method (14).

Diagram showing the relation between the ratio of ferric to ferrous iron and the colours of ochres, shades and clays.

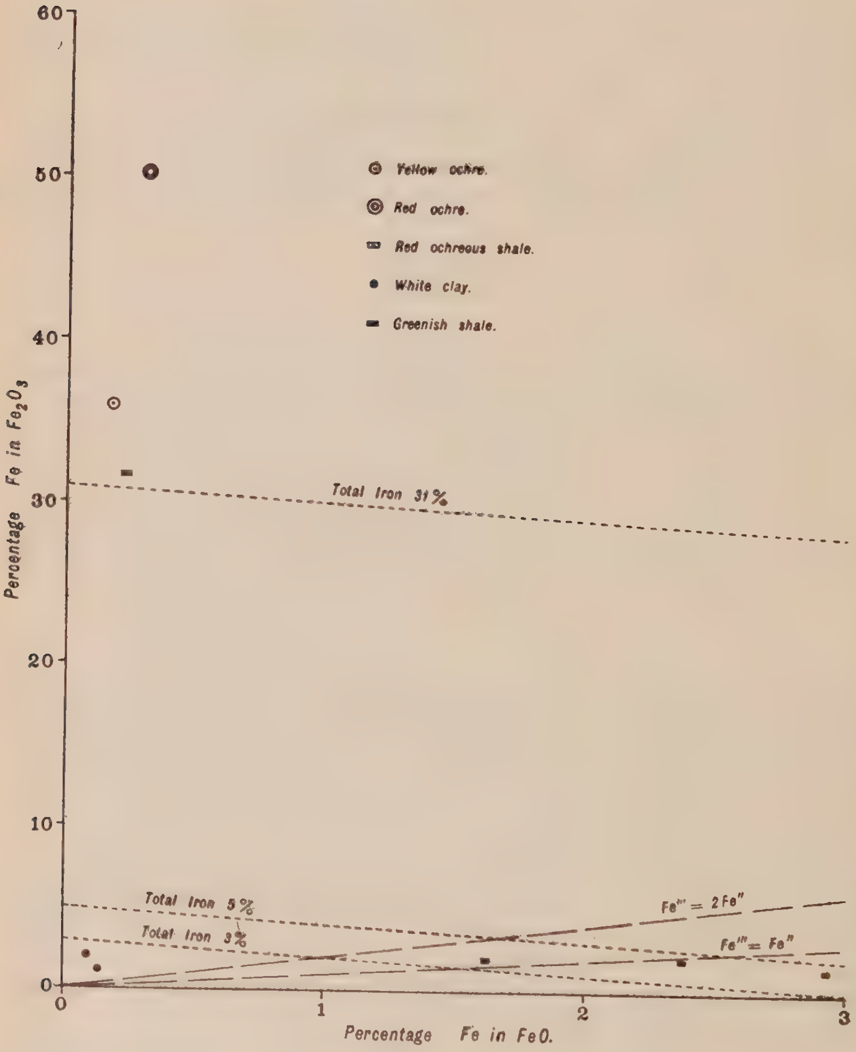

FIG. 3.

Sample.	Per cent. FeO.	Per cent. Fe in FeO.	Per cent. Fe_2O_3.	Per cent. Fe in Fe_2O_3.	$\frac{Fe'''}{Fe''}$
1	·22	·17	51·36	35·95	210·1
2	·39	·30	71·65	50·16	165·3
3	·11	·09	2·87	2·01	23·48
4	·17	·13	1·68	·118	8·89
5	·29	·23	45·28	31·62	140·5
6	3·05	2·37	2·80	1·96	·826
7	2·09	1·63	2·85	1·99	1·23
8	3·76	2·93	2·10	1·47	·503

The results are shown graphically in fig. 3.

From the graph it is evident that the change from true green Bokkeveld shale towards ochre takes place when Fe ''' exceeds 2Fe.'' Furthermore, the total iron content of the white clays is less than 3 per cent. ; for the green shales it lies between 3 and 5 per cent., whereas ochreous shales and ochres have an iron content above 30 per cent. Iron has therefore been leached from the shales to produce the clays, the ochres being due to an enrichment in iron.

The same phenomenon may be illustrated in a different way, by plotting the ratios of ferric to ferrous iron as abscissae and the percentages of ferric and ferrous oxides as ordinates. This gives two curves (fig. 4) intersecting in the point where $Fe''' : Fe'' = 1$. The antipathy of ferric and ferrous oxides in these shales, clays and ochres, which are clearly serially related, is well brought out. The graph shows that for true green shales $Fe'' > Fe'''$, (see also fig. 3) while an enrichment in iron gave rise to the ochres and ochreous shales.

During the process of bleaching of the Bokkeveld shales to form the white clays, the analyses show that iron has been leached away as Keller (8) demonstrated to be the case in the bleaching of the American Red Beds. The question remains, what was the solvent for the iron, in what form was it dissolved and in what form was it carried in solution?

Harrar (5) found that iron is most readily dissolved from ferrous oxide, then from limonite and least from ferric oxide. In order to react with an acid, the oxide must become hydrated, and this process is controlled by the solubility of the hydrate. Since the solubility of $Fe(OH)_2$ is comparatively much greater than that of $Fe(OH)_3$, and since in limonite a partial hydration has already occurred it is to be expected that $Fe(OH)_3$ would be the least soluble. Some of the supposedly weak organic acids dissolve remarkable quantities of iron and in natural solutions would be the most effective of all solvents.

Moore and Maynard (11) showed that carbonated water is the most effective solvent of iron and silica, with peat solution the next most efficient. Distilled water is a very poor solvent of iron but a

Diagram showing the correlation between ferrous and ferric oxides, and the green, white and red colours respectively of shades, clays and ochres.

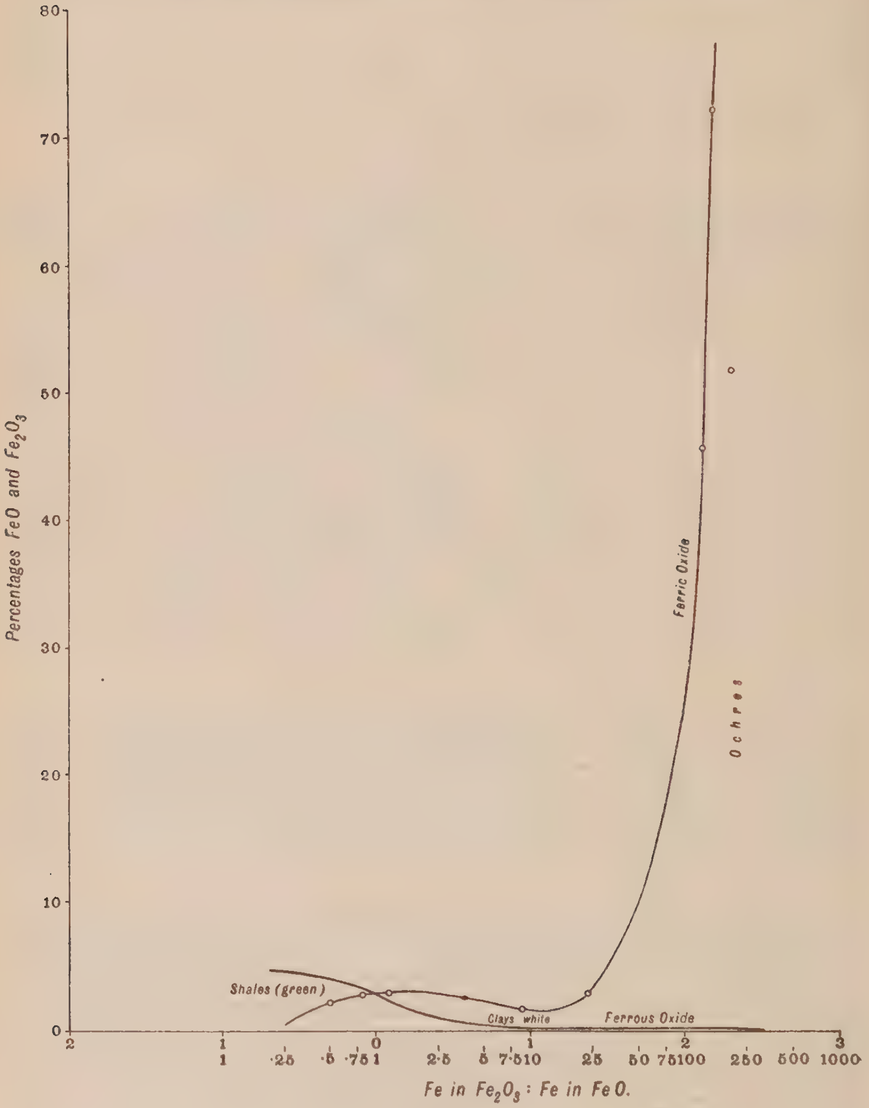

FIG. 4.

fairly active solvent of silica, whereas oxygenated water is as poor a solvent of iron and only a fair solvent of silica.

In cold natural surface waters high in organic matter iron is transported as a colloid, (a ferric oxide hydrosol) stabilised by organic colloids. As much as 36 parts per million ferric oxide can be held in a solution containing only 16 parts per million organic matter. Silica in solution in cold natural waters is also transported as a colliod provided the concentration does not exceed 25 parts per million. If the concentration is higher it is possible for a small percentage to be transported as an alkaline silicate.

Precipitation of colloidal solutions of ferric oxide is immediately brought about by electrolytes present in sea water and of the same concentration. Sodium chloride of the concentration of sea water (i.e. 34,400 p.pm.) or sea water itself are amongst the most efficeint precipitants of the silica hydrosol. In the presence of colloidal organic matter, both the silica and the ferric oxide hydrosol are stable in the same solution. On coming in contact with an electrolyte, such as those named above, ferric oxide is almost immediately precipitated, whereas precipitation of the silica starts after a considerable lapse of time and is complete only after some months.

Reviewing the facts in hand the conclusion may be drawn that the ochre was formed by surficial replacement (1) i.e. the iron was dissolved by natural surface waters from the upper portion of the Bokkeveld beds. Only ferrous iron, which was more susceptible to attack was leached out. This was oxidised, hydrated and carried downwards mainly along joints, cleavage and bedding planes and was, therefore, under ordinary temperature and pressure, except in so far as the heat of chemical reaction raised the temperature during the process of replacement. The main constituent that was replaced appears to be silica, while the hydrated ferric oxide was precipitated in its place.

The replacement of silica would depend on the rate at which it was removed from the field of reaction, and this again would depend on whether there was an easy passage for the circulation of the aqueous solutions. Thus, where the Bokkeveld was rendered fairly permeable by joints, cleavage and bedding planes and even minor faults, such as are frequently found, there would be a rapid circulation of iron-bearing solutions and rapid replacement of silica which could either be removed from the field of reaction or else held in solution without interfering with the precipitation of ferric oxide. With the faster reaction the temperature was raised above normal, resulting in partial dehydration of the ferric hydrates and the production of a hard inferior quality of ochre in fairly large masses. As the channels became choked by the hydrated ferric oxide deposits and the rapid circulation was arrested, the process of replacement went on more slowly, thus keeping the temperature at normal and causing the precipitation of the higher ferric hydrates, yielding an ochre of better quality surrounding the inferior deposits—exactly the state of affairs seen today at the ochre quarries.

Where the beds were more impervious, i.e. the solutions had to force their way into the underlying rock, the process of replacement was naturally slow, the temperature stayed at normal and only the higher ferric hydrates were produced. This explains the absence of very large individual deposits of high grade ochre.

Climate and Origin of the Surface Quartzites.

Intimately connected with the origin of the ochres is that of the surface quartzites which are present as a thin capping (up to 15 feet thick) in the ochre producing area and elsewhere ; in fact it seems to be part and parcel of the same process due to a variation in climate. The investigations of Kaiser on the siliceous Pomona quartzites of the Namib have led him to the conclusions that extensive silification of surface deposits is a metasomatic process that takes place only under extreme arid and normal arid climatic conditions when the superficial weathered material is not greatly disturbed by the action of wind (6). That in the case under consideration the silica came from the underlying rock is borne out by the analyses, and one can picture the process of formation of the surface quartzites as analogous to that by which tufaceous limestone is formed. Actually the two rock types have the same physical characteristics. Where the surface quartzite rests on clay it is porous, tufaceous and nodular while at the surface it is extremely hard and compact.

The peneplain on which the surface quartzites rest owes its origin to marine erosion, aided by river action, during a period of gentle uplift of the country. At that time the rainfall was moderate, and there was mild mechanical erosion and very little deposition in the area under discussion (semi-humid to semi-arid climate). Then the climate become drier (semi-arid to normal arid) ; there was no mechanical erosion and the water that fell on the surface could sink into the underlying rock leaching out the iron from the upper 15 feet of the Bokkeveld, leaving behind the white clays. The iron was deposited deeper down as a hydrated ferric oxide through a process of replacement. The climate then passed over to normal arid or extreme arid ; there was little or no precipitation and the above process was reversed. Through capillary action the ground water was brought to the surface, carrying in solution the silica set free during replacement, and depositing the same as the water evaporated at the surface. The process is naturally a slow one and the period of aridity must have been of considerable duration. After that climatic conditions reverted to semi-arid and the country was modelled into its present shape.

Age of the Deposits.

The age of the original source of the iron, the Bokkeveld beds, is considered to be Devonian. Though the ochres occur in these beds, they are secondary deposits and therefore clearly of later age. The occurence of similar ochre deposits both to the west and to the east of the producing area on the same peneplain, suggests that they were formed subsequent to the peneplanation of the country along the south coast. From the marine beds lying on portions of the peneplain in the Eastern Province it may be inferred that peneplanation took place in late Tertiary, probably Mio-Pliocene (7, 4) times. The process of formation of the ochre deposits have apparently gone on intermittently since the end of the Tertiary period and is no doubt still going on at present.

VI.—Some Economic Aspects.

Apart from the question of local and overseas markets for the raw material, successful mining of the ochres in the Riversdale district will depend on the following :—

(1) *Tonnage.*—It is impossible to estimate the reserves of ochre in the area owing to the small and often irregular size of the ore bodies, their scattered occurrence over a large area and the fact that no clue as to the whereabouts of an ochre body is found at the surface. From information gleaned from the little prospecting done in the area, the quarries in operation at present and at the present rate of production, all the companies see at least another 25 years' work ahead.

(2) *Cost of Production.*—This again depends on a thorough understanding of the behaviour of the ochre deposits, the uniformity of grade of the ochre and the possibility of sorting high grade ochre from inferior grades with comparative ease. The larger bodies of ochre, which are usually lense-shaped, after continuing for a few feet along the direction of strike of the country rock, peter out ; the same happens when following them downwards. Between individual ochre bodies there is not the slightest trace of connection and locating new deposits after one body has been removed is a matter of chance. Most of the companies, therefore, strip the clays in layers of about 3 feet thick until an ochre body is encountered. This naturally brings down the proportion of saleable ore to waste rock to a very low figure. On account of the softness of the clays and the fact that practically no explosives are required, the deposits lend themselves to inexpensive mining.

The more isolated the ochre bodies are—especially if they are surrounded by pure or slightly coloured clays as at Van As' quarries —the higher and more uniform is the grade. Where larger continuous masses of ochre occur in conjunction with nodules and bands of hard limonite, the grade is much lower, and good ochre often occurs next to lower grades. In such cases there is often a gradation from ochre to strongly coloured clays. The B.N. quarry of the African Golden Ochre Co., is a good illustration of this type.

To the experienced eye the sorting of high grade from inferior quality ochre or ochre from coloured clay presents no difficulty, but the work is of necessity slow. At the present rate of production hand sorting is the most effective and economical method of grading the ochre at the quarries.

The following table shows the average cost of production, prices realised and monthly output of the various companies in 1934.

	Monthly.	Cost or Production Transport Shipping.	Price Realised.
African Golden Ochre Co....	1st Grade, 100 tons....	£2 15s. 0d. per ton.	£5 10s. 0d. per ton.
	2nd Grade, 150 tons....	—	£3 10s. 0d. per ton.
Sunrise Ochre Mines	1st Grade, 25 tons......	£1 15 0d. per ton : production only	£3 0s. 0d. per ton.
	Red....................	—	£3 10s. 0d. per ton.
Van As' Ochre Mines	" Super," 130 tons.....	£3 4s. 0d. per ton, shipping at Cape Town.	£7 0s. 0d. per ton.

(3) *Transport.*—The railway from Capetown to Mossel Bay serves the area, the most distant quarries being about 5 miles from the nearest siding. The African Golden Ochre Co., transports all its ochre with its own lorry from the quarries to Albertinia station, which is about 12 miles from the farthest quarries. From Albertinia the ochre is railed to Mossel Bay (38 miles), where it is shipped for export to the Golden Valley Ochre and Oxide Co., of Bristol, England. Van As' ochre is carted by lorry to Zoutpan Siding, 4 miles south of the farthest quarry. It is railed to Capetown (276 miles) and there shipped for export. Roads are fair to good and run into all parts of the area.

(4) *Labour.*—White labour is almost exclusively used, being drawn from the surrounding country. Wages run to 3s. per day, plus a subsidy of 1s. per day from the Department of Labour since 1935. During the ploughing and harvesting seasons there is usually a scarcity of labourers.

(5) *Water Supplies.*—No water is required at the quarries, except for domestic use. In most cases the water is caught in tanks from the roofs of the storage sheds during the rainy season. The Sunrise Ochre Mines cart their water from Albertinia. In close proximity of the ochre quarries there are no flowing streams, springs or boreholes and the possibility of erecting a refining plant close to the quarries is practically ruled out.

VII.—CONCLUSION.

The following figures indicate the growth of the ochre industry in the Riversdale district during the last four years :—

	Production Tons of 2,000 lbs.	Sales Tons of 2,000 lbs.	Value of Sales.
			£
1932	2,081	1,897	6,131
1933	4,409	3,858	14,394
1934	3,691	3,520	12,908
1935	3,937	3,819	14,112
1936	6,085	5,585	21,270

There is still considerable ground for expanding the ochre industry. Only a small portion of the area over which ochreous shales and clays have been observed has up to the moment been tested, and extensive prospecting, such as can only be undertaken by a concern backed by some capital, is sure to show up new deposits. The favourable transport position, together with the ideal climatic conditions under which field work is carried out should further warrant the large scale exploitation of the ochre deposits, should there be an increase in demand.

Summary.

1. Interest is attached to the south-eastern portion of the Riversdale district, because of deposits of yellow and red ochre near Albertinia.

2. The area is occupied by highly inclined Bokkeveld beds forming a dissected peneplain capped by remnants of surface quartzite.

3. Underlying the quartzites are white and coloured clays—weathered Bokkeveld—in which the ochre is found.

4. The ochre occurs as small irregular masses or larger lenticular bodies orientated parallel to the strike and dip of the Bokkeveld beds.

5. Large masses of inferior quality ochre occurs around hard limonitic bands and nodules.

6. A sharp demarcation exists between ochre and white clays; in other cases there is a gradual transition.

7. The ochres have a beautiful golden yellow colour, which is kept up to standard by hand sorting. The hard varieties of ochre possess the same colour but lack in strength.

8. The experienced ochre miner can sort superior from inferior quality ochre with ease, and a high grade product can thus be obtained through hand-picking.

9. Treatment of the ochre at the quarries consists in drying only, a process to be controlled carefully on account of the ease with which ochre can dehydrate and change colour.

10. Three companies possessing about 12 quarries are at present producing ochre. Work is carried out in open paddocks and is mostly by pick and shovel.

11. Other occurrences of ochre beyond the Riversdale district are known in the Swellendam, Bredasdorp and Humansdorp districts.

12. The process of formation of the ochres is a metasomatic one, taking place under normal atmospheric conditions. The source of the iron is the Bokkeveld beds

13. The surface quartzites are supposed to have originated in a way similar to the ochres, only under different climatic conditions.

14. The age of the deposits is probably late Tertiary to Recent.

15. The erratic nature of the ochre deposits makes the estimation of tonnage impossible. Sufficient proof is available to warrant another 25 year's work at the present rate of production. If lower grades are also quarried, this period will undoubtedly be extended.

16 Cost of production is relatively low on account of the favourable transport position, fairly cheap labour, and the ease with which the ochre is quarried.

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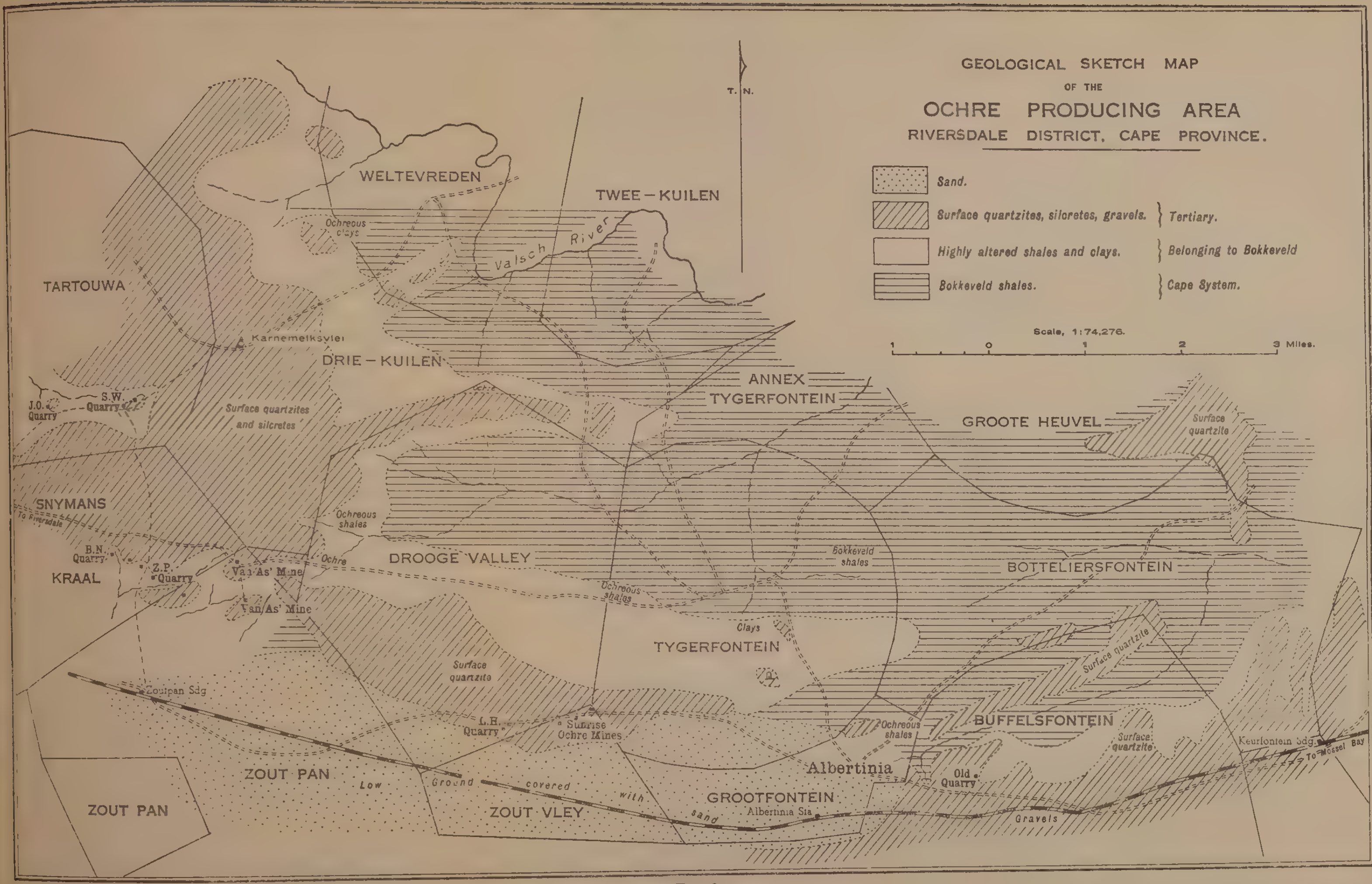
GEOLOGICAL SKETCH MAP
OF THE
OCHRE PRODUCING AREA
RIVERSDALE DISTRICT, CAPE PROVINCE.
Sand.
Surface quartzites, silcretes, gravels.
Tertiary.
Highly altered shales and clays.
Belonging to Bokkeveld
Bokkeveld shales.
Cape System.
Scale, 1:74,276.
1 0 1 2 3 Miles.
T. N.
WELTEVREDEN
TWEE – KUILEN
Valsch River
Ochreous clays
TARTOUWA
Karnemelksvlei
DRIE – KUILEN
ANNEX
TYGERFONTEIN
GROOTE HEUVEL
Surface quartzite
J.O. Quarry
S.W. Quarry
Surface quartzites and silcretes
Ochre
SNYMANS
To Riversdale
Ochreous shales
B.N. Quarry
KRAAL
Z.P. Quarry
Van As' Mine
Ochre
DROOGE VALLEY
Bokkeveld shales
BOTTELIERSFONTEIN
Ochreous shales
Van As' Mine
Clays
TYGERFONTEIN
Surface quartzite
Surface quartzite
Zoutpan Sdg
L.H. Quarry
Sunrise Ochre Mines
Ochreous shales
BUFFELSFONTEIN
Surface quartzite
Keurfontein Sdg.
To Mossel Bay
ZOUT PAN
Low Ground covered with sand
Albertinia
Old Quarry
ZOUT PAN
ZOUT VLEY
GROOTFONTEIN
Albertinia Sta
Gravels

FIG. 2.

NOTICE

THIS VOLUME IS INCOMPLETE

THE FOLLOWING ISSUES ARE NOT AVAILABLE:

NO. 10, 1939

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